CRM 95-168 / December 1995

Implementing Readiness-Based Sparing in the Marine Aviation Logistics Support Program: Readiness Implications

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REPORT DOCUMENTATION PAGE

Form Approved OMB No. 074-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	December 1995	Final

4. TITLE AND SUBTITLE
Implementing Readiness-Based Sparing in the Marine Aviation Logistics Support Program: Readiness Implications

5. FUNDING NUMBERS
C - N00014-91-C-0002

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Center for Naval Analyses
4401 Ford Avenue
Alexandria, Virginia 22302-1498

8. PERFORMING ORGANIZATION REPORT NUMBER
CRM 95-168

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 Words)***
The Marine Aviation Logistics Support Program (MALSP) was developed to ensure that all logistics support required for major regional contingency can be deployed quickly and efficiently when needed. The foundation for the MALSP is a set of standardized logistics support packages containing all the elements (spare parts, people, support equipment, and mobile facilities) required to support any contingency plan the Marine Corps may be tasked to execute. This study focuses on how the Marine should determine spare parts requirements for the MALSP.

14. SUBJECT TERMS
aviation, computerized, simulation, costs, input output models, logistics support, Marine Corps aviation, methodology, optempo, RBS (readiness based sparing), sorties, spare parts

15. NUMBER OF PAGES
54

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

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Summary

The Marine Aviation Logistics Support Program (MALSP) was developed to ensure that all logistics support required for a major regional contingency (MRC) can be deployed quickly and efficiently when needed. The foundation for the MALSP is a set of standardized logistics support packages containing all the elements (spare parts, people, support equipment, and mobile facilities) required to support any contingency plan the Marine Corps may be tasked to execute.

The Marine Corps now uses traditional demand-based sparing (DBS) methods to build spare parts inventories for these packages, but recent studies have demonstrated that readiness-based sparing (RBS) methods can provide more readiness for the dollar. RBS models determine the optimal mix of parts by linking supply resource requirements and their costs to readiness. This is accomplished by either sparing to a readiness objective while minimizing cost, or sparing to a cost objective while maximizing readiness.

We have two goals for this study:

- To assess the potential costs and benefits of implementing RBS in the MALSP
- To help the Marine Corps address the key issues associated with implementing RBS in the MALSP.

In [1], we discussed the cost and inventory implications of implementing RBS in the MALSP; in this report, we focus on the readiness implications. In our final report, we will address the key issues associated with implementing RBS in the MALSP, and will provide our recommendations on how the Marine Corps might want to proceed with the transition.

Key findings

These are our findings thus far:

- *The RBS algorithm provides more cost-effective MALSP spare parts packages than the pure DBS algorithm.* Performing straight "model-to-model" comparisons, we found that using the RBS algorithm to determine spare parts requirements for the MALSP always provided higher readiness for substantially less cost when compared to the pure DBS algorithm.

- *RBS spare parts packages are more cost-effective than the current DBS standard spare parts packages for the MALSP.*[1] We found that the Marine Corps could build RBS packages that are equal in cost to the current DBS packages, but that also increase readiness for a notional aviation combat element (ACE) by about 11 percentage points in wartime.

- *The amount of money currently being spent on spare parts for the MALSP is not enough to meet CNO deployed readiness goals.* We found that current spending on spare parts for the MALSP is about $139 million less per notional ACE than what the RBS models say is needed to meet CNO deployed readiness goals. Current spending is also about $227 million less per notional ACE than what the DBS models say is needed to ensure a 120-day self-sustaining capability in wartime.

- *Implementing RBS in the MALSP will have no negative side effects on other supply and maintenance related measures that impact readiness.* In fact, we found that implementing RBS in the MALSP will:

  — Improve the ACE's ability to meet planned wartime sortie rates

1. In reality, the Marines don't use the pure DBS model output to determine final spare parts requirements for the MALSP packages. Instead, they use various overrides and manual changes to modify allowance levels computed by the model. Spare parts packages that reflect these manual changes are called DBS standard packages.

— Reduce the need for squadron personnel to cannibalize aircraft

— Reduce the number of stockouts, thus improving component fill rates

— Reduce organizational-level turnaround times by reducing awaiting parts times.

Background

The Marine Aviation Logistics Support Program (MALSP) was developed to ensure that Marines could rapidly task organize and deploy the aviation logistics support needed to sustain flight operations in wartime. The MALSP is designed to provide the people, spare parts, mobile facilities, and support equipment needed to keep deployed shore-based Marine aircraft up and flying. The foundation for the MALSP is a set of standardized logistics support packages that are specifically designed to support any contingency plan the Marine Corps might be tasked to execute.

There are four types of MALSP packages. The fly-in support packages (FISPs) are designed to provide the spare parts needed for the first 30 days of a contingency, assuming no intermediate-level (I-level) repair capability in theater. The contingency support packages (CSPs) contain the spare parts, as well as the people, mobile facilities, and support equipment needed to establish an I-level repair capability in theater. There are two kinds of CSPs: peculiar contingency support packages (PCSPs) and common contingency support packages (CCSPs). PCSPs contain assets peculiar to specific types of aircraft, whereas CCSPs contain assets common to two or more types of aircraft.

Follow-on support packages (FOSPs) include assets that are required for sustained operations ashore, but are not necessarily required for initial flight operations. In short, FOSPs contain all the remaining assets required to flesh out the support that the FISPs and CSPs might not provide. Finally, training squadron allowances (TSAs) provide the necessary aviation logistics support for attached training squadrons in peacetime.

Currently, the Marine Corps determines spare parts requirements for shore-based Marine aircraft supported under the MALSP using traditional demand-based sparing (DBS) methods. But recent studies have

shown that an alternative called readiness-based sparing (RBS) can provide more aircraft readiness for the dollar [2,3]. RBS models accomplish this by selecting parts that maximize aircraft availability for least cost. Appendix A provides a comparative summary of the RBS and DBS methods for determining MALSP spare parts allowances.

What are the objectives of the study?

This study focuses on how the Marines should determine spare parts requirements for the MALSP. Specifically, we have been asked by the Deputy Chief of Staff for Aviation, Headquarters Marine Corps to help them answer two questions:

- What are the potential benefits and costs of implementing RBS in the MALSP?
- What are the key issues associated with implementing RBS in the MALSP?

Our first report [1] addressed the cost and inventory implications of implementing RBS in the MALSP. *This report addresses the readiness implications of implementing RBS in the MALSP.* Future work will focus on identifying and examining the key issues associated with a potential implementation of RBS in the MALSP.

What does this report cover?

This report has three sections. In the first, we discuss the approach we used for our analysis. We describe the simulation model as well as the scenario, assumptions, and model inputs and outputs we used for our analysis. In the second section, we present our analysis results. Specifically, we discuss the readiness implications of implementing RBS in the MALSP. We also look how RBS affects sortie completion rates, cannibalization rates, component fill rates, awaiting parts (AWP) times, and other supply and maintenance related measures that impact readiness. In the final section, we recap the key findings of our work thus far.

Approach

In this section, we present an overview of the approach we used to assess the readiness implications of implementing RBS in the MALSP. We'll start out by discussing the simulation model we used for the analysis. We'll then turn to a discussion of the scenario, key assumptions, and model inputs and outputs we used to estimate the readiness associated with alternative spare parts packages for the MALSP.

This was our general approach: First, we ran a baseline simulation designed to capture the readiness implications of employing a notional aviation combat element (ACE) and associated logistics support for a major regional contingency (MRC) using current DBS MALSP spare parts packages. We then ran a series of alternative simulations using several different hypothetical RBS and DBS MALSP spare parts packages.

For all cases, the simulations were identical except for the spare parts package used. We ran five iterations for each of the baseline and alternative simulations using the same five random number seeds for each simulation.[2] We then compared readiness results from the baseline and alternative simulations, and combined these results with our cost implications analysis to assess and compare the effectiveness of alternative MALSP spare parts packages.

The model

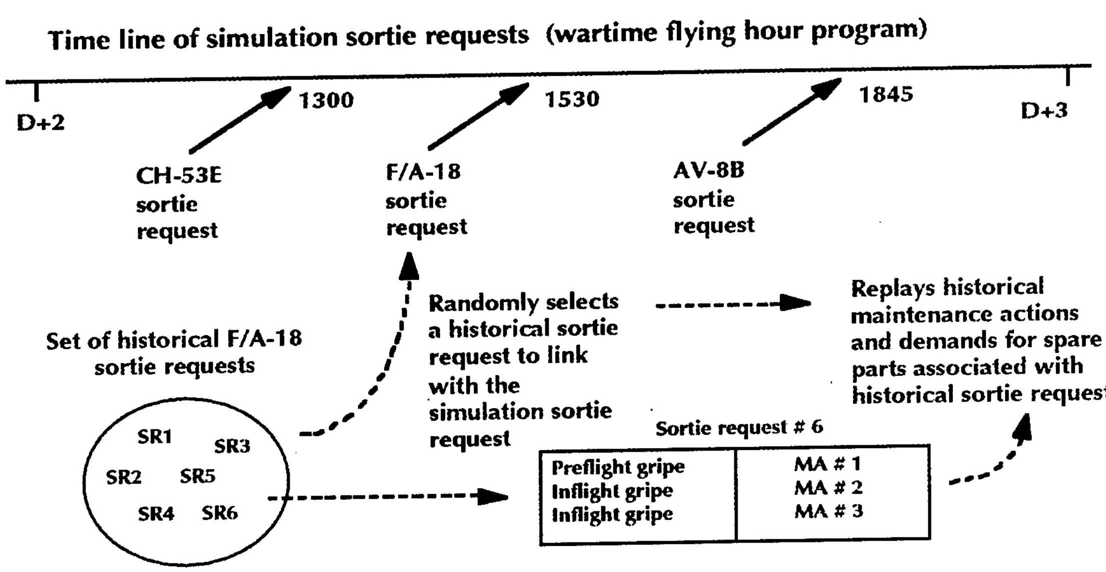
The simulation model we used to conduct the analysis was the Aviation Logistics Model (ALM) developed at CNA. ALM is designed to simulate the maintenance and supply activity associated with the

2. Cost factors limited the number of iterations we were able to run. However, we found little variation in our readiness measures from one run to another. As a result, we have a high level of confidence in our estimates even with only five iterations for each simulation.

repair of aircraft by the squadrons and the I-level repair facility. ALM is not like traditional Monte Carlo simulation models that make assumptions about demands for assets (such as spare parts, manpower, and test benches) based on known probability distributions. Instead, ALM uses actual maintenance data taken from historical 3M Visual Information Display System-Maintenance Action Forms (VIDS-MAFs) to predict how well the logistics support system maintains aircraft readiness and supports flight operations.

So how does ALM work? Figure 1 provides a road map for the discussion that follows. First, the user defines a scenario (that is, the mix of aircraft to be used, and the rate at which those aircraft will fly), as well as the capability of the aviation logistics support system (that is, maintenance manpower levels and initial spare parts levels). ALM then creates a simulation sortie time line. For each sortie flown, ALM randomly selects, with replacement, a sortie from a pool of historical sorties.

Figure 1. ALM basics—how the model works



Each of these historical sorties has associated maintenance and supply actions that were performed based on "gripes" identified either prior to, during, or after the historical flight. ALM models the execution of these actions based on the user-defined aviation logistics support system capability as well as data taken directly off the historical MAFs (for example, in-work maintenance time or elapsed maintenance time).

To illustrate, suppose an F/A-18C sortie request is scheduled for 1530 hours on day D+2 of the simulation run. A historical sortie request for an F/A-18C is selected with replacement from the collection of all F/A-18C historical sortie requests. In the model run, the sortie request occurs at the scheduled time, and following the sortie, the simulation model executes the maintenance actions (if any) that resulted from the historical sortie. That is, ALM will select actual MAFs associated with the historical sortie and will generate demands for manpower and spare parts based on the information contained in the historical MAFs. ALM will then use this information to simulate the changes in aircraft readiness status associated with maintenance performed on the aircraft. This information will then be used to calculate mission capable (MC) and fully mission capable (FMC) rates for specific type/model/series (TMS) aircraft.

ALM is a very effective tool for comparing two or more alternatives, such as alternative sparing policies (for instance, RBS versus DBS). However, ALM is not designed to project future performance (that is, it shouldn't be used to predict readiness). Because of this, we have chosen to present our results in terms of relative comparisons of readiness instead of absolute measures of readiness.

The scenario

We simulated the employment of a notional Marine Corps ACE and associated aviation logistics support for an MRC of 4 months duration. Table 1 shows the aircraft mix we used for our notional ACE.

Table 1. Aircraft mix for a notional Marine Corps ACE[a]

TMS aircraft	Number of squadrons	Number of aircraft
Fixed-wing	6	73
F/A-18	3	36
AV-8B	1	20
EA-6B	1	5
KC-130	1	12
Rotary-wing	6	87
CH-53E	1	16
CH-53D	1	8
CH-46E	3	36
AH-1W[b]	1	18
UH-1N[b]	1	9
Total	12	160

a. Source: HQMC ASL.
b. The AH-1Ws and UH-1Ns are combined into a single composite squadron consisting of 18 AH-1Ws and 9 UH-1Ns.

The MRC we simulated was a generic one, but modeled after what we would expect to see if the Marines were to go to war in Korea or the Middle East. During the first 30 days of our scenario, there was no I-level repair capability in theater. So in our simulation, the Marines relied exclusively on the FISPs to support flight operations for the first 30 days. This resulted in a backlog of I-level repairables during this period. After the first 30 days (on day D+31), we simulated the arrival of the aviation logistics support ships (also known as the T-AVBs) with the CSPs, which include the spare parts, people, support equipment, and maintenance vans required to establish an I-level repair capability in theater. From day D+31 through D+120 in our scenario, we simulated a fully functioning I-level repair capability in theater.[3]

Once the I-level repair capability arrived in theater, we also simulated reconstitution of the FISPs. That is, all the parts that failed during the first 30 days were repaired and then set aside for potential use in

3. We did not simulate engine rework activities. Our scenario assumed that this work was performed out of theater. In addition, we did not simulate employment of the FOSPs.

another near-simultaneous MRC if required. Once repaired, FISP parts were unavailable for the duration of the MRC.

The assumptions

The use of any simulation model requires making certain simplifying assumptions. The list that follows highlights some of the key assumptions we made for our simulations:

- All of the organizational level (O-level) support equipment required during the first 30 days and beyond was either off-loaded from the maritime prepositioning ships or flown in and was available for the duration of the MRC.
- All aircraft for the notional ACE arrived in theater on D-day, along with their FISPs.
- There was only limited offsite resupply of FISP parts during the first 30 days of the MRC. FISP parts were reordered only when stock levels fell to zero.
- There were two centralized locations for logistics support of the notional ACE aircraft: one fixed-wing site and one rotary-wing site.
- No logistics support of shore-based Marine aircraft was provided by sea-based activities during the MRC.
- We allowed for full cannibalization as required by the scenario.[4]
- Missed sorties were made up as mission-capable aircraft became available.
- Offsite resupply delays depended on the priority of the request. For our simulations, we used offsite resupply times from Operation Desert Shield/Storm.

4. Specifically, ALM chooses to cannibalize when two conditions have been met: The failed part is mission critical (in other words, the readiness status of the aircraft will be reduced without the part), and there are no more spare parts available in the supply inventory.

The inputs

In this section, we will review the key inputs we used for our simulation runs.

Historical data

As stated earlier, ALM uses historical maintenance and flight data to simulate a user-defined scenario. The historical data we used consisted of peacetime VIDS-MAFs and flight records from selected Marine Corps squadrons during the period January 1994 through June 1994. Table 2 provides a profile of the historical maintenance and flight data we used for our simulation. In summary, the historical data we used represent 6 months worth of flight and maintenance activity from 26 squadrons.

Table 2. Summary of historical flight and maintenance data

TMS aircraft	Total number of sorties	Total flight hours	Number of reporting aircraft	Total number of maintenance actions
F/A–18	11,771	21,567	93	8,767
AV–8B	3,759	8,817	56	4,142
EA–6B	956	2,514	10	2,435
KC–130	1,306	6,838	22	3,181
CH–53E	1,431	4,604	29	2,066
CH–53D	547	1,651	12	1,027
CH–46E	3,756	9,725	56	7,762
AH–1W/UH–1N	2,221	6,194	37	2,305

The VIDS-MAFs provide a historical record of what parts failed and how those parts were repaired. To use these data, we must to be able to link part numbers (which are used by the maintenance community) to national item identification numbers, or NIINs (which are used by the supply community). Whether or not we can "model" the supply activities associated with a failed part depends on whether we were able to link that part number with a NIIN from our spare parts inventory.

If a link is established, ALM "models" both the maintenance and supply activities associated with the repair of that part based on the constraints resulting from our user-defined aviation logistics support capability. That is, the time that the failed component is awaiting maintenance (AWM) or awaiting a replacement part (AWP) is determined by user-defined manpower and spare parts levels. The only information taken directly from the VIDS-MAF form is the in work (INW) time. If a link is not established, then ALM models only the maintenance activities associated with the repair of that part, and "defaults" the supply activities. That is, both the INW *and* AWP times that ALM uses are taken directly from the VIDS-MAF form, while the AWM time is determined by user-defined manpower levels.

We chose to "model" supply activities only for weapons-replaceable assemblies, or WRAs.[5] These are the major components on the aircraft. We chose to "default" supply activities for all shop-replaceable assemblies (SRAs) or subcomponents, as well as consumables and those WRAs for which part number to NIIN links could not be established.[6]

Operating tempo

Since we wanted to simulate our notional ACE flying at planned wartime flying hours (as stipulated in the Wartime Utilization Planning Data Documents for each TMS aircraft), we had to create a sortie schedule that reflected this increased level of flying. ALM accomplishes this by adjusting the historical flight data for each TMS aircraft to reflect higher levels of flying. For our simulation, we chose to have our aircraft fly a constant sortie schedule (where each TMS aircraft attempts to fly at the planned wartime utilization rate each month) as opposed to a variable sortie schedule (where each TMS aircraft attempts to fly at the average planned wartime utilization rate over

5. Within the Navy, the use of RBS is currently limited to determining spare parts allowances for WRAs only. SRA allowances are still determined using traditional DBS methods. Accordingly, we were only interested in "modeling" the supply activities associated with WRAs.

6. This last category represents a relatively small portion of the total parts for which we defaulted maintenance.

the 120-day period, but might not necessarily fly the planned rate each month).

Table 3 provides a summary profile of our simulated operating tempo. The table lists, by TMS aircraft, the average number of sorties flown per aircraft per month, the average number of flight hours per aircraft per month, and the average number of flight hours per sortie.

Table 3. Simulation sortie schedule

TMS aircraft	Average sorties (per AC per month)	Average flight hours (per AC per month)	Average flight hours per sortie
F/A–18C	39	68	1.7
F/A–18D	34	68	2.0
AV–8B	33	78	2.4
EA–6B	26	68	2.6
KC–130F	27	120	4.5
KC–130R	21	120	5.9
CH–53E	28	90	3.2
CH–53D	30	90	3.0
CH–46E	35	90	2.6
AH–1W	38	106	2.8
UH–1N	36	90	2.5

Aviation support system capability

The other key inputs to ALM are used to characterize the capability of the aviation logistics support system. The two key inputs here include maintenance manpower levels, and initial sparing levels for the MALSP spare parts packages.

Manpower levels

We modeled two I-level work centers for our scenario: one fixed wing and one rotary wing. Table 4 summarizes the manning levels we used for each work center. These numbers, provided by Headquarters Marine Corps, include the Marine Aviation Logistics Squadron (MALS) core, as well as squadron augment manning levels. They represent the number of nonadministrative personnel (also known as the wrench

turners) for the I-level repair facility. We assumed manning for wartime would be at 85 percent of the squadrons' table of organization (T/O).

Table 4. I-level facility manning for a notional ACE[a]

Category	Fixed-wing I-level manning	Rotary-wing I-level manning
MALS core	172	154
Squadron augments	314	207
T/O total	486	361
85% T/O total	413	307

a. Source: HQMC ASL.

Spare parts levels

To run ALM, we also need to input the initial spare parts levels contained in the MALSP spare parts packages. This is the only model input that we varied among our simulations; all others remained unchanged. In table 5, we summarize the spare parts packages we used for our baseline and alternative simulations. The costs in the table represent the total cost of the WRAs contained in the FISPs and CSPs for a notional ACE.

The following points briefly describe the spare parts packages we used in our simulations:

- *DBS standard (DBS STND).* The spare parts package for our baseline simulation represents the actual spare parts allowances and costs of the current restructured MALSP packages. These allowances reflect overrides and protections used during initial Naval Inventory Control Point, Philadelphia (NICP) sparing model runs, as well as manual adjustments made during the MALSP quality review conferences by NICP and fleet representatives. These allowances are designed to provide a 120-day self-sustaining capability for the notional ACE (30 days without I-level repair capability plus 90 days with I-level repair capability).

Table 5. ALM spare parts package summary[a]

Spare parts package	Description	FISP cost ($ millions)	CSP cost ($ millions)	Total cost ($ millions)
Baseline				
DBS STND	DBS standard	79	152	231
Alternatives				
DBS PURE	DBS pure	211	247	458
RBS READP	RBS readiness with protects	220	153	373
RBS READ	RBS readiness without protects	218	151	369
RBS COSTP	RBS cost with protects	106	152	258
RBS COST	RBS cost without protects	79	152	231

a. Source: [1].

- *DBS pure (DBS PURE).* Spare parts allowances and costs for this package reflect the direct DBS model output with no overrides or manual alterations.[7] Using this package allows us to perform straight "model-to-model" comparisons of DBS and RBS methods.
- *RBS readiness with protects (RBS READP).* This spare parts package replicates the Navy's initial concept for implementation of RBS. Allowances are spared to CNO deployed FMC goals assuming an average offsite resupply time of 25 days, a minimum protection level of 50 percent, and wartime flying hours (as stipulated in the Wartime Utilization Planning Data Documents for each aircraft type).
- *RBS readiness without protects (RBS READ).* This package is identical to RBS READP, except for the RBS minimum protection level. Here we assume a minimum protection of zero, which allows us to run RBS unconstrained. This means that RBS will set the minimum units of stock to be considered for each part equal to zero.
- *RBS cost with protects (RBS COSTP).* This package is identical to RBS READP, except for the sparing goal. Instead of sparing to a readiness goal, we spared to a cost goal. This cost equals that

7. We used DBS rules prescribed by ASO. These rules are identical to the Navy's range rule 12A and 85-percent whole depth rule.

for the DBS standard package, or the cost of the current restructured packages after all negotiations have been completed.

- *RBS cost without protects (RBS COST).* This spare parts package is identical to RBS COSTP, except for the RBS minimum protection level. Here we assume a minimum protection of zero, which allows us to run RBS unconstrained.

Each package described above had both a FISP and a CSP component. Spare parts available for use during the first 30 days of the simulation were limited to those in the FISP. From day D+31 to D+120 of the simulation, only CSP parts were available for use. Table 6 summarizes the mix of FISPs and CSPs we used for each of our simulations. These numbers represent the quantities that would be deployed to support a notional ACE in wartime. Additional details on how we built each of the spare parts packages described above can be found in [1].

Table 6. MALSP package mix required to support a notional ACE[a]

Type of aircraft supported	Number of aircraft supported	Number of FISPs	Number of PCSPs	Number of CCSPs
F/A-18	36	1	1	
AV-8B	20	1	1	
EA-6B	5	1	1	
KC-130	12	1	1	
CH-53E	16	1	1	
CH-53D	8	1	1	
CH-46E	36	1	1	
AH-1W/UH-1N	27	1	1	
Rotary wing	87			1
Fixed wing	73			1
Total	160	8	8	2

a. Source: HQMC ASL.

The outputs

ALM provides a wide range of measures that can be used to analyze simulation results. In this section, we summarize the five key measures of effectiveness (MOEs) that we used to assess the readiness implications of implementing RBS in the MALSP.

- *Readiness rates.* Our primary MOE was the average FMC readiness rate for a notional ACE. We calculated readiness rates by taking the aircraft uptime and dividing it by the total equipment-in-service time. This statistic helped us answer the question, "Does changing the sparing method to RBS result in higher aircraft readiness rates?"
- *Sortie rates.* Another MOE we used was the average number of completed sorties. This MOE helped us answer the question, "Does changing the sparing method to RBS cause the aircraft to miss more sorties?"
- *Cannibalization rates.* Our third MOE was the average cannibalization rate (that is, the average number of cannibalization actions per 100 flight hours). Squadron personnel sometimes resort to cannibalization when spare parts are not available from stock. This statistic helped us answer the question, "Does changing the sparing method to RBS cause squadron personnel to cannibalize more often?"
- *Component fill rates.* Our fourth MOE was the average fill rate for the WRAs in our spare parts packages. We calculated the fill rate as the total number of stockouts for each WRA divided by the total number of requisitions for that WRA. This statistic helped us answer the question, "Does changing the sparing method to RBS cause fill rates to decrease?"
- *O-level AWP times.* Our final MOE was the O-level AWP time, which is one of the components that makes up the O-level turnaround time (TAT). The AWP time provides an indication of how well the WRA sparing policy is supporting the aircraft. This statistic helped us to answer the question, "Does changing the sparing method to RBS cause O-level TATs (and specifically, O-level AWP times) to increase?"

Results

In this section, we present the results of our analysis of the readiness implications of implementing RBS in the MALSP. We'll start out by looking at CNO FMC readiness rates. We'll use these rates, along with our earlier cost analysis work in [1], to assess the relative cost-effectiveness of our DBS and alternative RBS spare parts packages. We'll then examine how using RBS might affect other readiness-related measures, such as sortie completion rates, cannibalization actions, component fill rates, and O-level AWP times.

Readiness rates

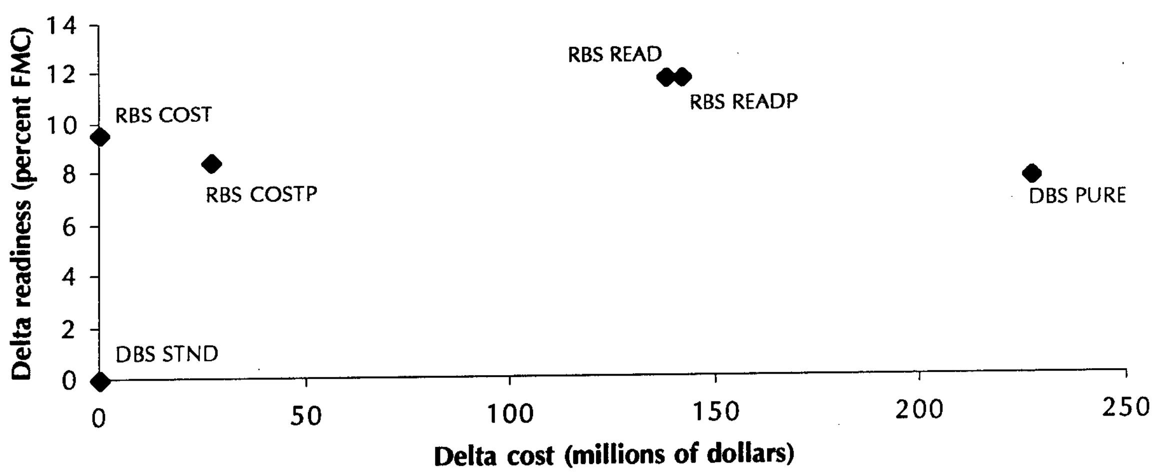
Does changing the sparing policy from DBS to RBS result in higher readiness rates for aircraft supported under the MALSP? We'll answer this question by first looking at average ACE readiness rates for the duration of the contingency. We'll then break those rates down further by looking at readiness rates for the first 30 days (D-day to D+30) and then for the remaining 90 days (D+31 to D+120) of the contingency.

FISPs and CSPs combined (D-day to D+120)

Figure 2 illustrates the readiness-to-cost relationships for our baseline and alternative spare parts packages for the duration of the contingency. All results are shown relative to our baseline DBS standard spare parts packages. The x-axis shows the average difference in costs for a notional ACE between our alternative spare parts packages and our baseline package, while the y-axis shows the average difference in readiness between the alternative and baseline packages. The differences in FMC rates in figure 2 represent averages for a notional ACE for the duration of the simulated war (120 days).

So what does figure 2 tell us about the relative cost-effectiveness of RBS and DBS spare parts packages for the MALSP? First, we can see that *the RBS algorithm outperforms the DBS algorithm.* Conducting straight "model-to-model" comparisons (that is, any RBS versus DBS PURE comparison) shows that the RBS algorithm provides higher readiness for less cost. When sparing to a cost goal, RBS provides two percentage points higher readiness for $227 million less than the pure DBS package. When sparing to a readiness goal, RBS provides over four percentage points higher readiness for about $89 million less.

Figure 2. Readiness-to-cost relationships for alternative MALSP packages—FISPs and CSPs combined



Second, we see that *RBS spare parts packages are more cost-effective than the current DBS standard spare parts packages for the MALSP.* For the same amount of money that is now being spent on spare parts for the MALSP, the Marine Corps could implement RBS (by sparing to a cost goal) and increase ACE readiness by about 10 percentage points on average.

Third, figure 2 shows that *the Marine Corps is currently spending less than what the RBS models say is required to meet CNO deployed readiness goals in wartime.* Implementing RBS by sparing to CNO readiness goals would increase the spare parts cost for a notional ACE by $138 million, but would also increase readiness rates by 12 percentage points on average for the duration of the contingency. In the next section, we'll see that the readiness impact of this dollar shortfall is felt most severely during the first 30 days of a contingency.

Fourth, we see that *the current method for determining spare parts requirements results in lower readiness than that provided by the pure DBS algorithm.* Although the cost of spare parts for a notional ACE is $227 million less using the current method, the result is a reduction in readiness of about eight percentage points when compared to what would be achieved using the direct DBS model output. In addition, we found that using the current method for determining spare parts requirements results in expenditures for spare parts that are significantly less than what the DBS models say is needed to ensure a 120-day self-sustaining capability with an 85-percent level of protection against stockout.

Finally, the figure illustrates clearly that *using minimum protects when implementing RBS provides no readiness benefits.* In fact, figure 2 shows that implementing RBS without protects provides the same or slightly higher readiness for less cost than if minimum protects were used.

FISPs (D-day to D+30)

Figure 3 shows the readiness-to-cost relationships for our baseline and alternative FISPs, which provide the spare parts support required for the first 30 days of a contingency. As before, all results are shown relative to our baseline DBS standard FISPs.

Figure 3 shows that *the Marines are currently spending substantially less on the FISPs than what the RBS models say is required to meet CNO deployed readiness goals for the first 30 days of a contingency.* For the FISPs, we find that implementing RBS by sparing to the cost of the current DBS standard FISPs would increase readiness for the ACE during the first 30 days of a contingency by about four percentage points, on average. However, if we chose to implement RBS by sparing to CNO

readiness goals, the Marine Corps would have to spend an additional $140 million to support a notional ACE, with an average readiness increase of about 11 percentage points during the first 30 days of the contingency.

The bottom line here is that implementing RBS in the FISPs by sparing to a cost goal will get the Marines closer to meeting CNO deployed readiness goals during the first 30 days of a contingency, but it still won't get them there. To accomplish this, the Marines will either have to spend more money on spare parts for the FISPs or make changes to either wartime requirements or the MALSP concept itself to make the FISPs more affordable. We plan to examine this last option in greater detail later in the study.

Figure 3. Readiness-to-cost relationships for alternative FISPs

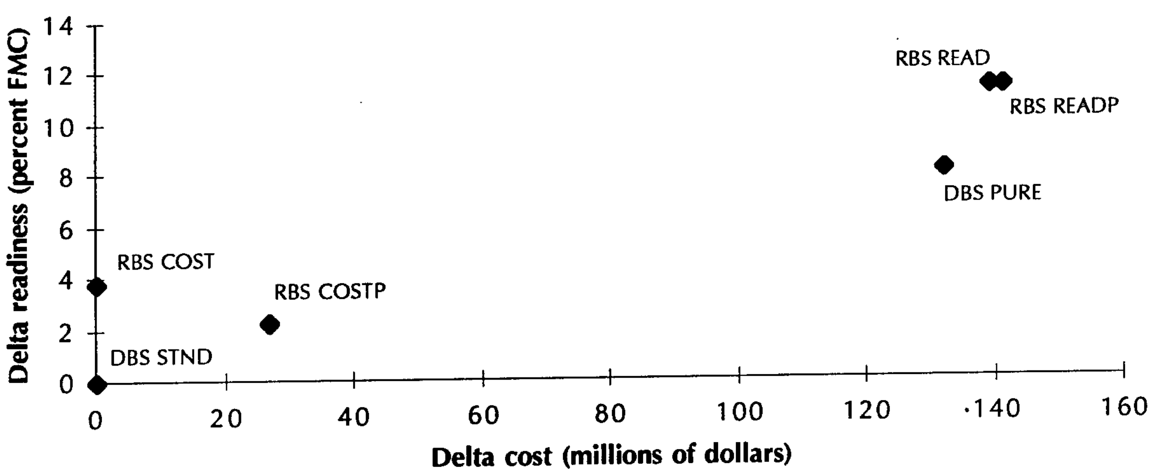


Figure 3 also shows that the current method for determining spare parts requirements for the FISPs results in lower readiness than that provided by the pure DBS algorithm. We can see that the amount of money the Marine Corps is now spending on spare parts for the FISPs is significantly less than what the DBS models say is needed to ensure a 30-day self-sustaining capability with an 85-percent level of protection against stockout. This shortfall (about $132 million for a notional

ACE) results in readiness that is about eight percentage points lower than what would be achieved if the direct DBS model output was used to determine allowances.

And finally, we see that there is no readiness benefit associated with using minimum protects when implementing RBS in the FISPs. For example, if the Marine Corps chose to implement RBS in the FISPs by sparing to a cost goal, it could get two percentage points more in readiness for $27 million less if it choose to implement without protects as opposed to implementing RBS with protects.

CSPs (D+31 to D+120)

Figure 4 shows the readiness-to-cost relationships for our baseline and alternative CSPs, which provide the spare parts support required for the contingency from day D+31 and on. This figure, like the previous two, illustrates the readiness benefits that could be realized by implementing RBS in the MALSP. Once again, we see that the RBS algorithm provides higher readiness for much less money than the pure DBS algorithm.

Figure 4. Readiness-to-cost relationships for alternative CSPs

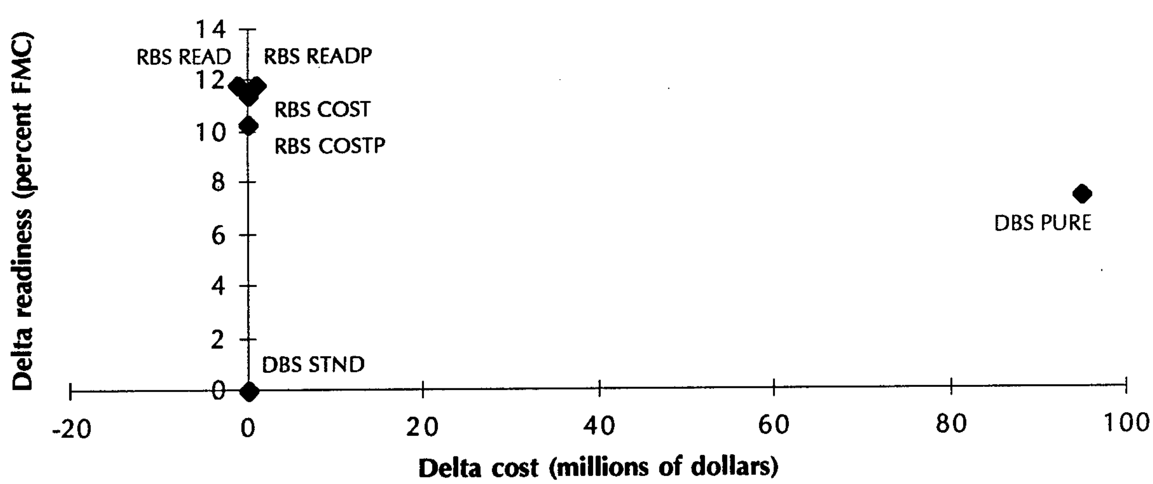


Figure 4 also illustrates that *the amount of money the Marine Corps is now spending on spare parts for the CSPs is about the same as what the RBS models say is required to meet CNO deployed readiness goals. However, the mix of parts currently chosen for the CSPs does not provide the same level of readiness as that achieved by the RBS spare parts packages.* This means that regardless of the sparing goal used (cost or readiness), the Marine Corps could implement RBS in the CSPs for the same amount of money it now spends on the MALSP and achieve, on average, a 10 to 12 percentage point increase in ACE readiness for day D+31 through D+120 of a contingency.

As was the case with the FISPs, we see that the current method for determining spare parts requirements for the CSPs results in lower readiness than that provided by the pure DBS algorithm. In addition, the amount of money the Marine Corps is now spending on spare parts for the CSPs is less than what the DBS models say is needed to ensure a 90-day self-sustaining capability with an 85-percent level of protection against stockout. This shortfall (about $95 million for a notional ACE) results in readiness that is almost eight percentage points lower than what would be achieved if the direct DBS model output was used to determine allowances. And lastly, we see that using minimum protects when implementing RBS in the CSPs provides no tangible readiness benefits.

Table 13 in appendix B provides a more detailed look at the results of our comparative analyses of readiness rates from our simulation runs. While readiness rates are the primary measure we used to assess the relative effectiveness of alternative sparing policies for the MALSP, we also looked at other measures that affect or are impacted by readiness in one way or another. These included sortie completion rates, cannibalization rates, component fill rates, and O-level AWP times. Examining these measures also gives us some indication of any possible negative effects associated with implementing RBS in the MALSP. In the following sections, we look at each of these measures in more detail.

Sortie completion rates

Does changing the sparing method to RBS cause the aircraft to miss more sorties, or does it improve the ACE's ability to meet planned sortie rates? Table 7 helps us answer this question by illustrating differences in the number of sorties completed for our baseline and alternative spare parts packages. The table also shows the differences in cost between the baseline and alternative spare parts packages for a notional ACE. All results are shown relative to our baseline DBS standard spare parts packages.

Table 7. Sortie completion rates for alternative MALSP spare parts packages[a]

	FISPs (D-day to D+30)		CSPs (D+31 to D+120)		FISPs and CSPs combined (D-day to D+120)	
Spare parts package	Delta cost ($ millions)	Delta sorties	Delta cost ($ millions)	Delta sorties	Delta cost ($ millions)	Delta sorties
DBS PURE	132	38	95	303	227	341
RBS READ	139	68	-1	370	138	438
RBS READP	141	68	1	370	142	438
RBS COST	0	12	0	380	0	392
RBS COSTP	27	−13	0	393	27	380

a. All results are shown relative to our baseline DBS standard spare parts package and reflect results for a notional ACE.

Table 7 illustrates that *implementing RBS in the MALSP will improve the ACE's ability to meet planned sortie rates.* For the same amount of money that is now being spent on spare parts for the MALSP, the Marines could implement RBS by sparing to a cost goal and fly an average of 392 more sorties over the duration of the contingency. Note also that most of the additional sorties would be flown during the last 90 days of the contingency, and not during the first 30 days.

If the Marines decided to implement RBS by sparing to CNO deployed readiness goals, the result would be an increase of about 438 sorties completed, but at a cost of about $138 million. This additional money would "buy" only about 68 additional sorties during the first 30 days the contingency.

Table 7 also shows that regardless of the method used to implement RBS in the MALSP, the RBS algorithm results in more sorties flown for less money when compared to the DBS pure algorithm. For example, when sparing to a cost goal, RBS provides about 51 more sorties on average for $227 million less. When sparing to a readiness goal, RBS allows the ACE to complete almost a hundred more sorties for $89 million less.

Finally, the table highlights the sortie-related drawbacks of using minimum protects when implementing RBS in the MALSP. For example, using minimum protects when implementing RBS by sparing to a cost goal results in about the same number of sorties completed for the duration of the contingency (about 12 less for the notional ACE, on average), but actually costs about $27 million more than if minimum protects were not used. Table 14 in appendix B provides a more detailed look at the results of our comparative analyses of sortie rates from our simulation runs.

Cannibalization rates

Does changing the sparing method to RBS cause squadron personnel to cannibalize more often, or does it reduce the need to cannibalize? Recall that squadron personnel are often forced to cannibalize parts in order to fill holes in aircraft and keep them flying. Unavailability of spare parts is the key driver for increasing cannibalization actions. The cannibalization policy we used in our simulation model required that two conditions be met before a cannibalization action could be initiated: (1) The failed part must be mission critical, and (2) there must be no more spare parts available in the supply inventory.

Table 8 shows differences in the number of cannibalizations per 100 flight hours for our baseline and alternative spare parts packages. As before, we also included the differences in cost between the baseline and alternative spare parts packages for a notional ACE. All results are shown relative to our baseline DBS standard spare parts packages.

Table 8 illustrates that *implementing RBS in the MALSP will reduce the need for squadron personnel to cannibalize in wartime.* The finding is true regardless of the type of sparing goal we use when implementing RBS.

For example, if the Marines chose to implement RBS by sparing to the cost of the current MALSP spare parts packages, the cannibalization rate would be cut by about eight cannibalizations per 100 flight hours during the first 30 days of the contingency, and by about nine for the duration of the contingency. The results would be even more dramatic if we chose to implement RBS by sparing to CNO readiness goals. In this case, the cannibalization rate would be cut more than ten cannibalizations per 100 flight hours for the duration of the contingency.

Table 8. Cannibalization rates for alternative MALSP spare parts packages[a]

Spare parts package	FISPs (D-day to D+30) Delta cost ($ millions)	FISPs (D-day to D+30) Delta canns (per 100 FH)	CSPs (D+31 to D+120) Delta cost ($ millions)	CSPs (D+31 to D+120) Delta canns (per 100 FH)	FISPs and CSPs combined (D-day to D+120) Delta cost ($ millions)	FISPs and CSPs combined (D-day to D+120) Delta canns (per 100 FH)
DBS PURE	132	−11.5	95	−7.2	227	−8.3
RBS READ	139	−13.8	−1	−8.9	138	−10.1
RBS READP	141	−13.8	1	−8.9	142	−10.1
RBS COST	0	−7.9	0	−9.2	0	−8.9
RBS COSTP	27	−4.3	0	−8.9	27	−7.8

a. All results are shown relative to our baseline DBS standard spare parts packages and reflect results for a notional ACE.

And once again, we can see how the RBS algorithm outperforms the DBS algorithm. Table 8 shows that if we compare any of the RBS packages to the DBS PURE package, the RBS packages will always result in fewer cannibalizations at less cost. Finally, the table shows how using minimum protects affects cannibalization rates when implementing RBS in the MALSP. In general, we can see that the use of minimum protects results in equivalent or higher cannibalization rates at a higher cost. Table 15 in appendix B provides a more detailed look at the results of our comparative analyses of cannibalization rates from our simulation runs.

Component fill rates

Does changing the sparing method to RBS cause fill rates for the WRAs in our spare parts packages to decrease, or does it improve component fill rates? Table 9 helps us answer this question by illustrating differences in WRA fill rates for our baseline and alternative spare parts packages. We calculated average fill rates by taking the total number of stockouts for each WRA and dividing this number by the total number of requisitions for that WRA. All results are shown relative to our baseline DBS standard spare parts packages.

Table 9. Component fill rates for alternative MALSP spare parts packages[a]

	FISPs (D-day to D+30)		CSPs (D+31 to D+120)		FISPs and CSPs combined (D-day to D+120)	
Spare parts package	Delta cost ($ millions)	Delta fill rate (pct. pnts)	Delta cost ($ millions)	Delta fill rate (pct. pnts)	Delta cost ($ millions)	Delta fill rate (pct. pnts)
DBS PURE	132	36	95	17	227	22
RBS READ	139	44	−1	23	138	28
RBS READP	141	44	1	23	142	28
RBS COST	0	25	0	24	0	24
RBS COSTP	27	12	0	24	27	21

a. All results are shown relative to our baseline DBS standard spare parts packages and reflect results for a notional ACE.

Table 9 illustrates that *implementing RBS in the MALSP will reduce the number of stockouts, thus improving WRA fill rates.* We can see that depending on the method used, implementing RBS in the MALSP could increase WRA fill rates by anywhere from 21 to 28 percentage points, on average. Specifically, if the Marines were to implement RBS in the FISPs by sparing to a cost goal, they could improve WRA fill rates during the first 30 days of the contingency by 25 percentage points on average without spending any additional money. Fill rates would actually double (from 44 percent to 88 percent, on average) during the first 30 days if the Marines implemented RBS in the FISPs

by sparing to CNO readiness goals. Of course, this dramatic improvement in fill rates would come at a cost of $139 million for a notional ACE.

Table 9 also shows that substantial improvements in WRA fill rates during the period D+31 through D+120 (about 23 to 24 percentage points, on average) could be achieved at no extra cost by implementing RBS in the CSPs. Additional results here are similar to what we have seen for our other MOEs, namely that:

- The RBS algorithm performs better than the DBS algorithm. Straight "model-to-model" comparisons show that regardless of the sparing goal, RBS spare parts packages provide better fill rates for less money than DBS pure spare parts packages.
- The RBS algorithm is more effective when no minimum protects are used. Implementing RBS without minimum protects will always produce the same or higher fill rates for less money.

Table 16 in appendix B provides a more detailed look at the results of our comparative analyses of component fill rates from our simulation runs.

O-level AWP times

Does changing the sparing method to RBS cause O-level AWP time (and thus, O-level TATs) to increase, or does it result in lower AWP times? As mentioned previously, the O-level AWP time provides a good indication of how well the WRA sparing policy is supporting the aircraft. Table 10 illustrates differences in O-level AWP times for our baseline and alternative spare parts packages. All results are shown relative to our baseline DBS standard spare parts packages.

Table 10 shows that *implementing RBS in the MALSP will reduce O-level TATs by reducing AWP times.* During the first 30 days of a contingency, O-level AWP times could be reduced about 11 hours on average by implementing RBS and sparing to the cost of the current spare parts package. Implementing RBS by sparing to CNO deployed readiness goals would reduce the O-level AWP time by about 20 hours during

Table 10. O-level AWP times for alternative MALSP spare parts packages[a]

Spare parts package	FISPs (D-day to D+30)		CSPs (D+31 to D+120)		FISPs and CSPs combined (D-day to D+120)	
	Delta cost ($ millions)	Delta AWP time (hours)	Delta cost ($ millions)	Delta AWP time (hours)	Delta cost ($ millions)	Delta AWP time (hours)
DBS PURE	132	−16	95	−9	227	−10
RBS READ	139	−20	−1	−17	138	−18
RBS READP	141	−20	1	−17	142	−18
RBS COST	0	−11	0	−14	0	−14
RBS COSTP	27	−3	0	−11	27	−9

a. All results are shown relative to our baseline DBS standard spare parts packages and reflect results for a notional ACE.

the first 30 days of a contingency, but would add $139 million to the cost of the FISPs for a notional ACE.

Our conclusions are similar when we look at results for the duration of the contingency. For example, implementing RBS by sparing to a cost goal would reduce O-level AWP times by 14 hours for no additional cost. If the Marines decided to implement RBS by sparing to CNO deployed readiness goals, O-level AWP times would be reduced by 18 hours (which represents a 70-percent reduction, on average).

Once again, our results show that the RBS algorithm outperforms the DBS algorithm. RBS resulted in lower O-level AWP times for less money. And finally, we again found that the most effective way to implement RBS in the MALSP is to do so without minimum protects. Table 17 in appendix B provides a more detailed look at the results of our comparative analyses of O-level AWP times from our simulation runs.

Recap

Table 11 summarizes the readiness implications of implementing RBS in the MALSP. To recap, our interim findings show the following:

- The RBS algorithm provides more cost-effective MALSP spare parts packages than the pure DBS algorithm.
- The RBS algorithm provides more cost-effective MALSP spare parts packages than the current DBS standard spare parts packages. This means that implementing RBS at current funding levels would actually increase readiness rates.
- The amount of money now being spent on MALSP spare parts is not enough to meet CNO deployed readiness goals.
- Using minimum protects when implementing RBS in the MALSP would provide no readiness benefits.
- Implementing RBS in the MALSP will improve other readiness-related measures such as sortie rates, cannibalization rates, component fill rates, and O-level AWP times.

In our final report, we plan to address the key issues associated with a potential implementation of RBS in the MALSP and make recommendations as to how the Marine Corps might want to proceed with the transition.

Table 11. Summary of readiness implications of alternative MALSP spare parts packages for a notional ACE[a]

Alternative spare parts packages	FMC rates (pct. pnts)	Sortie rates (no. sorties)	Cann rates (per 100 flight hrs)	WRA fill rates (pct. pnts)	O-level AWP time (hours)	Cost ($ millions)
FISPs (D-day to D+30)						
DBS PURE	+8.1	+38	−11.5	+36	−16	+132
RBS READ	+11.4	+68	−13.8	+44	−20	+139
RBS READP	+11.4	+68	−13.8	+44	−20	+141
RBS COST	+3.8	+12	−7.9	+25	−11	0
RBS COSTP	+2.3	−13	−4.3	+12	−3	+27
CSPs (D+31 to D+120)						
DBS PURE	+7.4	+303	−7.2	+17	−9	+95
RBS READ	+11.8	+370	−8.9	+23	−17	−1
RBS READP	+11.8	+370	−8.9	+23	−17	+1
RBS COST	+11.4	+380	−9.2	+24	−14	0
RBS COSTP	+10.3	+393	−8.9	+24	−11	0
FISPs and CSPs (D-day to D+120)						
DBS PURE	+7.7	+341	−8.3	+22	−10	+227
RBS READ	+11.7	+438	−10.1	+28	−18	+138
RBS READP	+11.7	+438	−10.1	+28	−18	+142
RBS COST	+9.6	+392	−8.9	+24	−14	0
RBS COSTP	+8.4	+380	−7.8	+21	−9	+27

a. All results are shown relative to our baseline DBS standard spare parts packages, and reflect results for a notional ACE.

Appendix A: Sparing methodology comparison

In this appendix, we provide a quick overview and comparison of two alternative sparing methods for determining spare parts requirements for the MALSP packages: demand-based sparing (DBS) and readiness-based sparing (RBS).

The DBS method

The Naval Inventory Control Point, Philadelphia (NICP) uses DBS models to determine spare parts allowances for the MALSP packages. In reality, NICP doesn't use a "pure" DBS algorithm to compute sparing levels. Instead, various overrides, protections, and manual changes are used to modify and alter allowance levels computed by the model. Reasons for these manual alterations include strategic lift, peacetime support, cost, and usage data considerations.

The DBS models provide the starting point for the MALSP allowance determination process. Initial allowances are computed using historical fleetwide component failure data. A number of overrides and protections are used during these initial model runs. Manual changes are then made to these preliminary allowances. These adjusted allowances are then sent out to the fleet for review and validation. Fleet units will compare their site-specific usage data with allowances computed in the sparing model runs. A MALSP quality review conference is then held at NICP. The purpose of this conference is to bring fleet representatives and NICP together to verify allowance levels for individual components, and adjust them as required. Joint decisions are then made based on recent usage data, component cost, and other factors.

The RBS method

RBS is an alternative to the current DBS method for computing spare parts allowances in the MALSP. RBS represents a fundamentally different way of thinking about sparing. Instead of determining allowances for each part independently of all others, RBS determines allowances by considering all parts together. RBS determines the optimal mix of parts by linking supply resource requirements and their cost to readiness in one of two ways: (1) by meeting a readiness objective for least cost or (2) by meeting a cost objective for maximum readiness.

Within the Navy, RBS is currently limited to determining allowances for weapons-replaceable assemblies (WRAs), which are the major components on the aircraft. The Navy continues to use DBS methods to determine shop-replaceable assemblies (SRA), or subcomponent allowances. The reason for this has to do with data information retrieval problems that keeps the Navy from capturing failure dependencies between parent (WRA) and child (SRA) components.

Comparing the two methods

Table 12 summarizes the differences between the RBS and DBS algorithms.

As we stated before, RBS is now used to determine requirements for WRAs only. DBS is used to determine requirements for both WRAs and SRAs. Both methods use the same component usage data: (1) the rate at which components fail; (2) the frequency with which failed components can be locally repaired; and (3) the length of time it takes to locally repair failed components (known as the turnaround-time, or TAT).

Some of the parameters used as inputs for the two models are the same, while others differ significantly. Both methods use wartime flying hours to reflect the operating tempo of the aircraft. In addition, both use identical force levels (that is, the number of aircraft being supported).

Table 12. Comparison of the DBS and RBS sparing methods

Characteristic	DBS algorithm	RBS algorithm
Components	– WRAs and SRAs	– WRAs only
Usage data	– Failure rates – I-level repair capability – Turnaround times	– Failure rates – I-level repair capability – Turnaround times
Parameters	– Optemo — Wartime flying hours – Force levels (number of aircraft) – Offsite resupply time — None – Endurance period — 30 days for FISPs, 90 for CSPs – Safety level — 85-percent whole protection – I-level repair capability — None for FISPs, full for CSPs	– Optemo — Wartime flying hours – Force levels (number of aircraft) – Offsite resupply time — 25 days for FISPs and CSPs – Endurance period — None – Safety level — 50-percent or zero min. protect – I-level repair capability — None for FISPs, full for CSP
Sparing goal	– Ensure a self-sustaining capability for 30 or 90 days with an 85-percent protection against stockout	– Ensure CNO deployed readiness goals are attained for least cost, or ensure cost goal is achieved for maximum readiness
Other characteristics	– Does not consider cost – Does not link resources to readiness – Considers each component independently of all others	– Considers cost – Links resources to readiness – Considers all components together

RBS models use an offsite resupply time which represents the amount of time it takes to get resupplied once failed components that cannot be locally repaired are sent offsite for repair. We chose a 25-day offsite resupply time for our primary RBS runs. DBS-based fly-in support packages (FISPs) and contingency support packages (CSPs) do not use offsite resupply times. Instead, they make use of what is called an endurance period. The endurance period represents the length of time a self-sustaining capability is ensured. This is 30 days for FISPs and 90 days for CSPs. Endurance periods do not apply to RBS models.

We can also see from table 12 that DBS models make use of a safety level. FISPs and CSPs use an 85-percent level of protection against stockout. RBS models can be run with or without minimum protects, which serve essentially the same purpose as DBS safety levels but are calculated differently. Running RBS with no minimum protects allows the model to run unconstrained, providing the optimal solution. However, RBS models can also be run with minimum protects (usually 50 percent). A minimum protection level of 50 percent means that the smallest quantity of stock the model will consider for a particular part is that part's mean repair and resupply pipeline.

The sparing goals are fundamently different for the two methods. DBS models are used to ensure a self-sustaining capability for a certain period of time (30 days for FISPs, 90 days for CSPs) with a certain level of protection against stockout (85 percent). RBS models, on the other hand, are used to ensure that either CNO deployed readiness goals are achieved for least cost, or that a specific cost objective is met for maximum readiness. These are very different objectives, so their impact on spare parts cost will differ considerably.

Other basic characteristics of the models differ as well. Unlike RBS models, DBS models do not link resources to readiness. Likewise, DBS models do not consider cost-effectiveness when determining allowances. In addition, DBS models consider each component independently of all others when determining allowances, whereas RBS models consider all components together.

Appendix B: Detailed comparative analyses

This appendix provides some detailed comparative statistics for our five measures of effectiveness (MOEs), which included:

- Fully mission capable (FMC) readiness rates
- Sortie completion rates
- Cannibalization rates
- Component fill rates
- O-level awaiting parts (AWP) times.

The tables that follow contain average differences between all possible pair-wise comparisons of our baseline and alternative spare parts packages for each of the five MOEs listed above. We also included standard deviations for each of the differences. Since we used the same sequence of random numbers for each of our baseline and alternative simulations, we calculated average differences by pairing results from each simulation based on the random number seed used. Standard deviations were then calculated from the paired differences.

Table 13. FMC readiness rate comparisons for alternative MALSP spare parts packages (standard deviations are in parentheses)[a]

Packages compared	FISPs (D-day to D+30) Delta FMC rate (percentage pts)	CSPs (D+31 to D+120) Delta FMC rate (percentage pts)	FISPs and CSPs (D-day to D+120) Delta FMC rate (percentage pts)
DBS PURE vs.DBS STND	+8.1 (0.2)	+7.4 (1.7)	+7.7 (1.2)
RBS READ vs. DBS STND	+11.4 (0.7)	+11.8 (1.0)	+11.7 (0.7)
RBS READP vs. DBS STND	+11.4 (0.7)	+11.8 (1.0)	+11.7 (0.7)
RBS COST vs. DBS STND	+3.8 (0.9)	+11.4 (0.9)	+9.6 (0.6)
RBS COSTP vs. DBS STND	+2.3 (0.5)	+10.3 (1.1)	+8.4 (0.8)
DBS PURE vs. RBS READ	−3.2 (0.8)	−4.4 (1.9)	−4.1 (1.3)
RBS READP vs. RBS READ	+0.0 (0.0)	+0.0 (0.0)	+0.0 (0.0)
RBS COST vs. RBS READ	−7.6 (1.1)	−0.4 (0.2)	−2.2 (0.2)
RBS COSTP vs. RBS READ	−9.0 (1.1)	−1.5 (0.7)	−3.3 (0.8)
DBS PURE vs. RBS COST	+4.4 (0.8)	−4.1 (2.0)	−1.9 (1.3)
RBS READP vs. RBS COST	+7.6 (1.1)	−0.4 (0.2)	+2.2 (0.2)
RBS COSTP vs. RBS COST	−1.5 (1.3)	−1.1 (0.8)	−1.1 (0.7)
DBS PURE vs. RBS READP	−3.2 (0.8)	−4.4 (1.9)	−4.1 (1.3)
RBS COSTP vs. RBS READP	−9.0 (1.1)	−1.5 (0.7)	−3.3 (0.8)
DBS PURE vs. RBS COSTP	+5.8 (0.7)	−3.0 (1.8)	−0.8 (1.6)

a. These numbers reflect results for a notional Marine Corps aviation combat element (ACE) consisting of 160 aircraft (73 fixed-wing and 87 rotary-wing).

Table 14. Sortie completion rate comparisons for alternative MALSP spare parts packages (standard deviations are in parentheses)[a]

Packages compared	FISPs (D-day to D+30) Delta sortie rate (number of sorties)		CSPs (D+31 to D+120) Delta sortie rate (number of sorties)		FISPs and CSPs (D-day to D+120) Delta sortie rate (number of sorties)	
DBS PURE vs.DBS STND	+38.2	(20.4)	+302.8	(179.0)	+341.0	(180.7)
RBS READ vs. DBS STND	+67.6	(42.0)	+370.0	(160.6)	+437.6	(149.5)
RBS READP vs. DBS STND	+67.6	(42.0)	+370.0	(160.6)	+437.6	(149.5)
RBS COST vs. DBS STND	+12.4	(23.0)	+380.0	(173.9)	+392.4	(180.1)
RBS COSTP vs. DBS STND	−13.0	(40.9)	+393.0	(174.0)	+380.0	(166.5)
DBS PURE vs. RBS READ	−29.4	(25.0)	−67.2	(42.9)	−96.6	(54.0)
RBS READP vs. RBS READ	+0.0	(0.0)	+0.0	(0.0)	+0.0	(0.0)
RBS COST vs. RBS READ	−55.2	(32.5)	+10.0	(21.5)	−45.2	(40.6)
RBS COSTP vs. RBS READ	−80.6	(42.5)	+23.0	(28.9)	−57.6	(65.0)
DBS PURE vs. RBS COST	+25.8	(14.2)	−77.2	(23.5)	−51.4	(35.5)
RBS READP vs. RBS COST	+55.2	(32.5)	−10.0	(21.5)	+45.2	(40.6)
RBS COSTP vs. RBS COST	−25.4	(44.6)	+13.0	(30.6)	−12.4	(49.0)
DBS PURE vs. RBS READP	−29.4	(25.0)	−67.2	(42.9)	−96.6	(54.0)
RBS COSTP vs. RBS READP	−80.6	(42.5)	+23.0	(28.9)	−57.6	(65.0)
DBS PURE vs. RBS COSTP	+51.2	(39.0)	−90.2	(46.7)	−39.0	(50.6)

a. These numbers reflect results for a notional Marine Corps ACE consisting of 160 aircraft (73 fixed-wing and 87 rotary-wing).

Table 15. Cannibalization rate comparisons for alternative MALSP spare parts packages (standard deviations are in parentheses)[a]

Packages compared	FISPs (D-day to D+30) Delta cann rate (canns per 100 FH)	CSPs (D+31 to D+120) Delta cann rate (canns per 100 FH)	FISPs and CSPs (D-day to D+120) Delta cann rate (canns per 100 FH)
DBS PURE vs.DBS STND	−11.5 (0.4)	−7.2 (0.2)	−8.3 (0.2)
RBS READ vs. DBS STND	−13.8 (0.5)	−8.9 (0.2)	−10.1 (0.2)
RBS READP vs. DBS STND	−13.8 (0.5)	−8.9 (0.2)	−10.1 (0.2)
RBS COST vs. DBS STND	−7.9 (0.4)	−9.2 (0.3)	−8.9 (0.3)
RBS COSTP vs. DBS STND	−4.3 (0.2)	−8.9 (0.4)	−7.8 (0.3)
DBS PURE vs. RBS READ	+2.3 (0.2)	+1.6 (0.1)	+1.8 (0.1)
RBS READP vs. RBS READ	+0.0 (0.0)	+0.0 (0.0)	+0.0 (0.0)
RBS COST vs. RBS READ	+5.9 (0.5)	−0.3 (0.2)	+1.3 (0.2)
RBS COSTP vs. RBS READ	+9.5 (0.4)	+0.0 (0.2)	+2.3 (0.2)
DBS PURE vs. RBS COST	−3.6 (0.5)	+1.9 (0.2)	+0.5 (0.2)
RBS READP vs. RBS COST	−5.9 (0.5)	+0.3 (0.2)	−1.3 (0.2)
RBS COSTP vs. RBS COST	+3.6 (0.4)	+0.2 (0.1)	+1.0 (0.1)
DBS PURE vs. RBS READP	+2.3 (0.2)	+1.6 (0.1)	+1.8 (0.1)
RBS COSTP vs. RBS READP	+9.5 (0.4)	+0.0 (0.2)	+2.3 (0.2)
DBS PURE vs. RBS COSTP	−7.2 (0.3)	+1.6 (0.2)	−0.6 (0.1)

a. These numbers reflect results for a notional Marine Corps ACE consisting of 160 aircraft (73 fixed-wing and 87 rotary-wing).

Table 16. Component fill rate comparisons for alternative MALSP spare parts packages (standard deviations are in parentheses)[a]

Packages compared	FISPs (D-day to D+30) Delta WRA fill rate (percentage pts)	CSPs (D+31 to D+120) Delta WRA fill rate (percentage pts)	FISPs and CSPs (D-day to D+120) Delta WRA fill rate (percentage pts)
DBS PURE vs.DBS STND	+35.7 (0.7)	+17.5 (0.8)	+22.0 (0.5)
RBS READ vs. DBS STND	+44.1 (0.6)	+22.8 (1.1)	+28.1 (0.9)
RBS READP vs. DBS STND	+44.1 (0.6)	+22.8 (1.1)	+28.1 (0.9)
RBS COST vs. DBS STND	+24.6 (1.3)	+24.2 (1.2)	+24.3 (1.2)
RBS COSTP vs. DBS STND	+11.9 (1.1)	+24.0 (1.2)	+21.0 (1.1)
DBS PURE vs. RBS READ	−8.4 (0.8)	−5.1 (0.8)	−5.9 (0.4)
RBS READP vs. RBS READ	+0.0 (0.0)	+0.0 (0.0)	+0.0 (0.0)
RBS COST vs. RBS READ	−19.5 (1.1)	+1.4 (0.4)	−3.8 (0.5)
RBS COSTP vs. RBS READ	−32.3 (1.1)	+1.0 (0.4)	−7.3 (0.4)
DBS PURE vs. RBS COST	+11.1 (1.0)	−6.3 (0.8)	−1.9 (0.6)
RBS READP vs. RBS COST	+19.5 (1.1)	−1.4 (0.4)	+3.8 (0.5)
RBS COSTP vs. RBS COST	−12.8 (1.2)	−0.3 (0.3)	−3.4 (0.4)
DBS PURE vs. RBS READP	−8.4 (0.8)	−5.1 (0.8)	−5.9 (0.4)
RBS COSTP vs. RBS READP	−32.3 (1.1)	+1.0 (0.4)	−7.3 (0.4)
DBS PURE vs. RBS COSTP	+23.8 (1.0)	−6.1 (1.2)	+1.3 (0.8)

a. These numbers reflect results for a notional Marine Corps ACE consisting of 160 aircraft (73 fixed-wing and 87 rotary-wing).

Table 17. O-level AWP time comparisons for alternative MALSP spare parts packages (standard deviations are in parentheses)[a]

Packages compared	FISPs (D-day to D+30) Delta AWP time (hours)	CSPs (D+31 to D+120) Delta AWP time (hours)	FISPs and CSPs (D-day to D+120) Delta AWP time (hours)
DBS PURE vs.DBS STND	−16.1 (0.9)	−8.5 (2.5)	−10.4 (1.8)
RBS READ vs. DBS STND	−20.6 (1.2)	−16.9 (2.5)	−17.9 (1.8)
RBS READP vs. DBS STND	−20.6 (1.2)	−16.9 (2.5)	−17.9 (1.8)
RBS COST vs. DBS STND	−11.5 (1.0)	−14.3 (1.8)	−13.6 (1.3)
RBS COSTP vs. DBS STND	−2.5 (2.2)	−11.4 (2.2)	−9.2 (1.1)
DBS PURE vs. RBS READ	+4.5 (0.8)	+8.4 (1.2)	+7.4 (1.1)
RBS READP vs. RBS READ	+0.0 (0.0)	+0.0 (0.0)	+0.0 (0.0)
RBS COST vs. RBS READ	+9.1 (0.6)	+2.6 (1.5)	+4.2 (1.2)
RBS COSTP vs. RBS READ	+18.1 (1.1)	+5.6 (1.9)	+8.7 (1.4)
DBS PURE vs. RBS COST	−4.6 (0.9)	+5.8 (1.1)	+3.2 (0.9)
RBS READP vs. RBS COST	−9.1 (0.6)	−2.6 (1.5)	−4.2 (1.2)
RBS COSTP vs. RBS COST	+8.9 (1.5)	+3.0 (1.0)	+4.5 (0.7)
DBS PURE vs. RBS READP	+4.5 (0.8)	+8.4 (1.2)	+7.4 (1.1)
RBS COSTP vs. RBS READP	+18.1 (1.1)	+5.6 (1.9)	+8.7 (1.4)
DBS PURE vs. RBS COSTP	−13.5 (1.7)	+2.9 (1.3)	−1.3 (1.0)

a. These numbers reflect results for a notional Marine Corps ACE consisting of 160 aircraft (73 fixed-wing and 87 rotary-wing).

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[2] CNA Research Memorandum 94-140, *Analysis of America's Readiness-Based Sparing Aviation Consolidated Allowance List,* by Anne J. Hale, Aug 1994

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